



Geant 4



# Joint FNAL v Experiment Simulations Planning Mtg

---

Robert Hatcher  
Fermilab Computing Division

ad hoc mtg 2012-04-23



# Who & What



Geant4



- Representatives of running and upcoming v experiments who are involved with simulations
- To discuss, plan & prioritize activities that can be shared amongst more than one expt:
  - Beam Simulations (flux)
  - Event Generation (cross sections & kinematics)
  - Expt Agnostic Detector Simulations (e.g. Geant4)
    - up through energy depositions; nothing detector specific
      - i.e. not light/electron propagation, or electronics (e.g. DAQ)
      - LArSoft share ( $\mu$ Boone + LBNE + ArgoNeut), but not this mtg focus
- Common concerns for all 3 areas:
  - Validation of the physics
  - Evaluation of systematic errors



# Overview of Current State



**Geant4** ● Some sharing; some disjoint efforts; some not covered



- beam simulation
  - gnumi, g4numi, flugg (g4+fluka)
  - Already a joint NuMI beam effort (started July 2011)
    - biweekly meetings
    - this meeting is not a substitute; just awareness raising and prioritizing effort in the the larger context
- neutrino physics
  - currently GENIE for all but MINOS+ (NEUGEN3, though possibly GENIE as well)
- detector physics
  - Geant4 for all but MINOS+ (Geant3, depends on VMC interface)
- “nusoft” effort under ART framework
  - shared by LAr + NOvA
  - interface to GENIE and Geant4





# Beam Simulation



## Geant 4



- Common Ntuple format
  - gnumi (geant3, obsolete)
  - flugg (g4+fluka, incomplete)
  - g4numi (+ minerva + lbne variants)
- Shared location for non-expt specific files
- Common mechanism for converting to GSimpleNtpFlux format
  - samples weighted files into form with unweighted rays
  - factorize computation speeds up actual generation
- Merge codebase back to one repository
  - snapshots taken at various times means history was lost, but fixes need to get propagated to multiple repositories
  - experiment based branches from common code allows desired flexibility
- Re-work flugg handling of alternatives
  - use run-time switches, not code recompilation
- Evolve flugg for full ancestor list
  - currently doesn't have all particles between initial proton and particle that decayed to give the neutrino
  - can't apply NA59/NA61 weights
- Physics choices
  - Geant4 PhysicsList alternatives
  - flugg fluka version (2011)
- Incorporation of external knowledge
  - NA49/NA61
  - cross expt hadron re-weighting
    - SKZP works for MINOS but not NOvA
  - revisit muon/hadron monitors?



# Neutrino Physics Simulation



Geant 4



- GENIE collab efforts
  - hA vs. hN internuclear scattering
  - cross section re-tuning (inc. new data)
    - still same as NEUGEN3
  - incorporate np-nh (coherent multi-nucleon) scattering
  - validation (Costas did some for T2K - what can be generalized, reused)
- FNAL GENIE maintenance
  - common build (sort of already)
  - synchronize experiments?
  - request tags from GENIE collaboration
- maxpathlength use and determination
  - is rate sensitive to relative proportions?
    - box vs. flux method
    - might explain Minerva issue?
- Alternative Generator
  - fluka/peanut?
  - incorporate into framework (nusoft)
- Flux components
  - efficient beam  $\nu_e$  handling
- GSimpleNtpFlux speedup
  - new GFluxl interfaces: Index(), etc
    - not possible on x-y weighted form
- Rock/overlay handling
  - rock model of underground area
  - file merging (nusoft/ART framework)
- GENIE x-sec splines
  - common generation of all (A,Z)
  - reduction to only (A,Z) need by expt
  - study # of knots vs. precision
    - size issue (currently 200)
    - log spacing 0.01-200 GeV
- Refactorize/cleanup GENIEHelper (nusoft)
  - handle flux files lists
  - conversion of genie::EventRecord to/from simb::MCTruth w/out loss
- Other GENIE mods
  - Flux “Exposure” mix-in interface
  - flux file list (+wildcard) handling
  - validate POTs accounting
  - alternative fiducial/rock selector



# Detector Simulation (e.g. Geant4)



**Geant 4**



## ● PhysicsList

- appropriate energy regime
- correct physics
- extensibility (exotics)

## ● TestBeam

- validation using existing data (Minerva, MINOS?, others?)
- planning for new testbeams (NOvA, others?)

## ● Rock event speedup

- prune low energy particles before they can be propagated by Geant4
- while propagating
- in G3 one could adjust tracking media parameters (precision, explicit delta-ray production); is that possible in G4?

## ● Handling excited nuclei

- GENIE leave them undecayed
- Geant4 or standalone before G4?

## ● Anomalies

- electron shower shapes
  - Urban93 multiple scattering in thin non-dense medium
  - small characteristic  $\theta_0$  turns into a  $\cos\theta$  far from 1
- check on muon-nucleus scattering

## ● Alternatives?

- geant3, fluka (via VMC?)





# Additional Resources



## Geant 4 • NuSoft-ART



- GENIEHelper

- G4Base

- SimulationBase

- <https://cdcv.sfnal.gov/redmine/projects/nusoftart/wiki>

## • GENIE work at FNAL

- <https://cdcv.sfnal.gov/redmine/projects/genie/wiki>

## • Both redmine areas have issue trackers

- only GENIE one has entries, not heavily updated



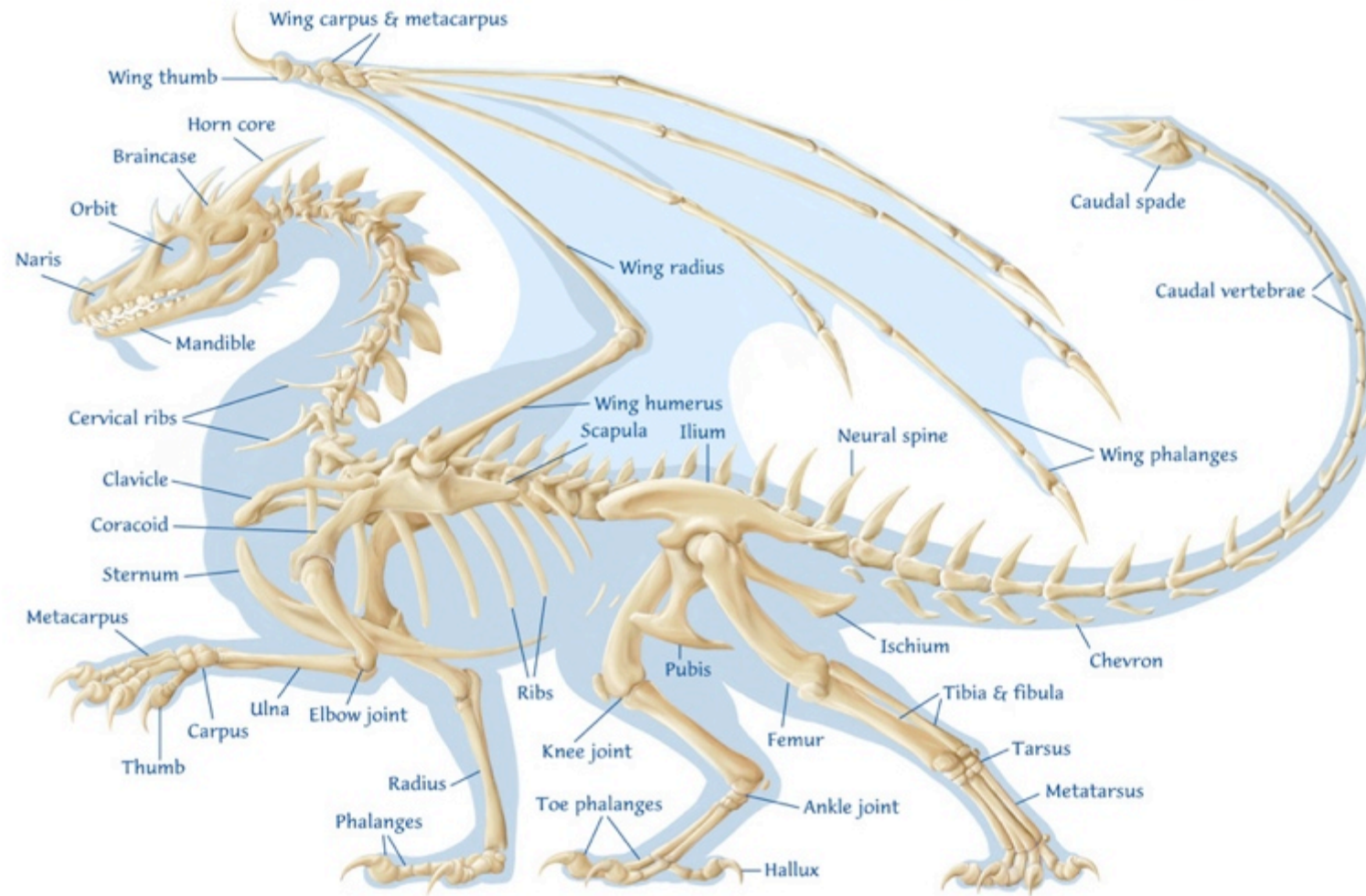
# Here be dragons



## Geant 4



### Dragon anatomy: Skeleton



Copyright © 1997 Art and design: Eugene Arenhaus Idea and production: Jennifer Walker All rights reserved

- mini-talks on a few items follow...





# test beam



**Geant 4** ● funding issues for new testbeams...



- beamline, containment, safety, actual detector...
- NOvA & LAr synergy possible?
- tertiary beam for low energy
- comes late in experiment for NOvA (not before)



# maxpathlength



**Geant4** ● sets overall normalization for rejection method



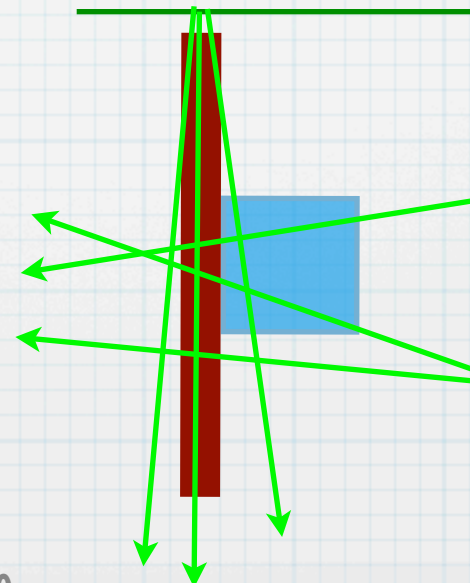
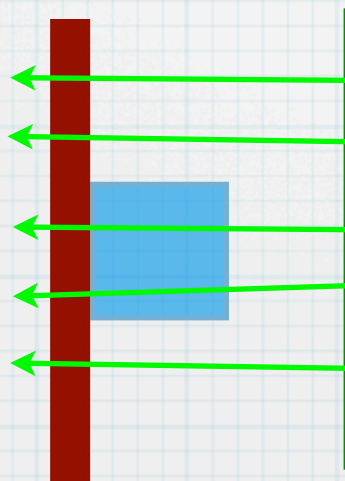
● based on scan of geometry; two methods:

● random points, rays from 3 surfaces of a box

● rays pulled from the flux source

● scans will see different proportions of (A,Z)

```
<path_length pdgc="1000010010">1638.66</path_length>  
<path_length pdgc="1000060120">11964.8</path_length>  
<path_length pdgc="1000260560">13825.2</path_length>
```





xyzyzy



Geant 4

